RELIABILITY STUDY OF DIESEL ENGINE OPERATING WITH BIODIESEL

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Report submitted in partial of the requirements
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FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled "Reliability Study of Diesel Engine Operating with Biodiesel" is written by Muhamad Harif Bin Ghani. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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SUPERVISOR’S DECLARATION

I hereby declare that I have checked this report and in my opinion this report is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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Date : 6 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

Signature

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Date : 6 DECEMBER 2010

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ABSTRACT

The use of alternative fuels issues: reducing the reliance on unstable supply of oil, reduce harmful emissions, and using renewable energy sources. This thesis focuses on the comparison of the four-engine reliability cylinder turbocharged diesel engine operating on diesel fuel and biodiesel. Steady-state tests conducted for the experiment to determine how the input energy adapted form of fuel down the machine. Over energy measured for the loss of engine coolant and exhaust, power output is used, as and light and untold losses. Results showed that the energy input of biodiesel distributed 37.4%, 31.1% and 29.6% into the main area air, exhaust, and power output, respectively. Similarly, to include energy distributed diesel 37.5%, 31.4% and 29.2% of the main areas of air, exhaust pipe, and output power, respectively. It is concluded from an uncertainty Analysis that there was no statistically significant difference in the results. Future improvements to obtain distinguished results are described.

ABSTRAK

Masalah penggunaan bahan bakar alternatif mengurangkan pergantungan pada bekalan minyak tidak stabil, mengurangkan pembebasan berbahaya dan menggunakan sumber tenaga yang boleh diperbaharui. Tesis ini tertumpu pada perbandingan kebolehpercayaan enjin diesel beroperasi pada minyak diesel dan biodiesel.

Steady-state ujian yang dilakukan untuk percubaan juga menentukan bagaimana bentuk tenaga masuk yang disesuaikan pada bahan bakar kepada enjin diesel. Lebih daripada tenaga yang diukur atas kehilangan pendingin enjin dan output kuasa knalpot, digunakan, dan kerugian sebagai cahaya dan tak terhitung. Keputusan kajian menunjukkan bahawa input tenaga biodiesel diedarkan 37,4%, 31,1% dan 29,6% ke udara pada kawasan utama, knalpot, dan daya keluaran, masing-masing. Demikian pula, untuk memasukkan tenaga diedarkan diesel 37,5%, 31,4% dan 29,2% dari kawasan utama hawa, paip ekzos, dan daya keluaran, masing-masing. Hal ini disimpulkan daripada analisis ketidakpastian yang tidak ada perbezaan yang signifikan secara statistik dalam keputusan.Pembaikan masa depan untuk mendapatkan hasil yang dijelaskan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Exh	Exhaust Gas Temperature

CHAPTER 1

INTRODUCTION

1.1 PURPOSE

Diesel engines are broadly used in medium and heavy duty applications because of their lower fuel consumption, higher brake thermal efficiency and lower emissions (such as CO and HC) compared with gasoline engines. Depletion of petroleum derivates increases the research interest in the area of alternative fuels. The high viscosity and low volatility raw vegetables oils are generally considered to be the major drawbacks for their utilization as fuels in diesel engines. The usage of raw vegetables oils in diesel engines leads to injector coking, severe engine deposits, filter gumming problems, piston ring sticking and thickening of the lubricating oil. However, these effects can be reduced through the esterification of the vegetables oil to form monoesters called as biodiesels. Biodiesel produced from the non- edible Jatropha oil decrease viscosity and improves the cetana number and heating value. (Abdelghaffar, 2002)

The development of computer technology narrows down the time consumptions for the sophisticated engine test through the simulation techniques. The insight of the combustion process is to be analyzed thoroughly, which enhance the power output of the engine and consider as the heart of the engine process. Thermodynamic models are mainly based on the first law of thermodynamics and are used to analyze the combustion and performance characteristics of engines.The purpose of writing this thesis is to study the reliability of diesel engines using biodiesel and diesel operations. Understand theperformance characteristics diesel engine operating diesel fuel and biodiesel fuel(Mohamed N. Saeed, 2002).

1.2 GOAL

Engine reliability study is the first step to study the alternative fuel sources in the near future. This is the main reason for reaching the final goal of this thesis.The aim is to determine the amount of energy received by the diesel engine throughfuel source and then measuring the output energy and losses throughout the system.

1.3 OBJECTIVE

The objective of this project is to study the reliability of diesel engine operating with diesel fuel and biodiesel fuel.

1.4 SCOPE

i. Study of effect performance characteristics diesel engine operating with biodiesel fuel and diesel fuel.
ii. Collect data temperatureand pressure with DEWE software.
iii. Compare data from diesel fuel and biodiesel fuel operating with diesel engine.

1.5 PROBLEM STATEMENT

There has been plenty of research done so far on emissions testing both diesel and biodiesel. Research in the area of biodiesel has shifted towards making it more economically feasible by lowering production costs and increasing the energetic yields from various feedstocks. Where the research has been lacking is in relation to the better characterization of the performance of these fuels in all possible diesel applications.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

To get the right content in this thesis, it is important to analyze the development of diesel engines up to date, background information on biodiesel and the need for alternative fuels, and some background information on these programs.

2.2 DIESEL ENGINE DEVELOPMENT

The compression ignition engine was developed in 1892 by the German engineer, Dr.Rudolf Diesel (Leduc, 2007). It was developed for using a variety of fuel sources such ascoal dust or peanut oil and it was shown at the 1900 World Exhibition in Paris, France(Leduc, 2007). Here peanut oil was the chosen fuel for the demonstration. In the early1900's, Dr. Diesel was making statements implying that the use of the diesel engine withrenewable fuels would help stimulate agricultural markets and that the renewable oilsmay someday be as valuable as petroleum and coal products (Leduc, 2007). It seems thatday is fast approaching.The standard diesel engine operates on the principal that air in the engine cylinder iscompressed to an extremely high pressure and temperature at which time the fuel isinjected into the combustion chamber causing ignition. This is different from a gasolineengine which compresses both the air and fuel at the same time. Once the air and fuel iscompressed, the gasoline engine relies on a spark to ignite the mixture causingcombustion. The spark ignition or gasoline engine's need for electrical ignition requiresthe use of many components such as spark plugs, ignition coil, distributor, and acarburetor. The mechanical nature of the diesel engine's design makes it simpler, morerugged, more versatile, and its higher compression ratio makes it more efficient than thegasoline engine. It is because of these basic principles of the diesel engine's design thatmake it such a good candidate for a near term solution to our renewable energy needs (Engine Manufacturers Association, 2002).

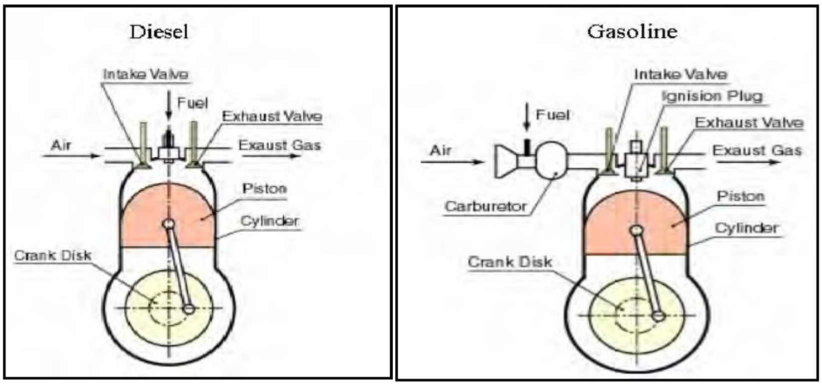

Figure 2.1: shows a basic schematic of a diesel and gasoline engine, respectively

Source: Engine Manufacturers Association 2002

Figure 2.1 shows the schematic layout of diesel and gasoline engines. The traditional drawbacks of the diesel engine are their cold weather operation, noisiness,pollution, and lack of power. However, with advancements in technology, almost all ofthese issues have been resolved. The most significant improvements were due toimprovements to the fuel injection and air induction systems. Traditional diesel enginesused indirect injection (IDI) systems where the fuel would enter a prechamber andpartially combust there. Currently most diesel engines use direct injection (DI) systemswhere the injector tip is directed straight into the cylinder's combustion chamber.

Theresult of this improved design is a quieter, cleaner, and more powerful engine.Improvements to injection pumps and fuel injectors including higher pressures, multipleinjections per stroke, and optimized spray patterns have improved combustionefficiencies resulting in more power, quieter delivery, and lower emissions from morecomplete combustion.Advancements in diesel engine air induction systems have really propelled their use intoa variety of applications. The use of turbo chargers takes advantage of otherwise wastedexhaust gases to help deliver more intake air to the engine's combustion chambers. Theforce from hot exhaust gases entering the turbocharger spins a turbine connected to acompressor. The compressed air is then supplied to the engine increasing power andlowering emissions. Figure 2.2 shows the 2003 Cummins 5.9 L diesel engines and itscommon rail fuel system (Memmolo and Sam, 2008).

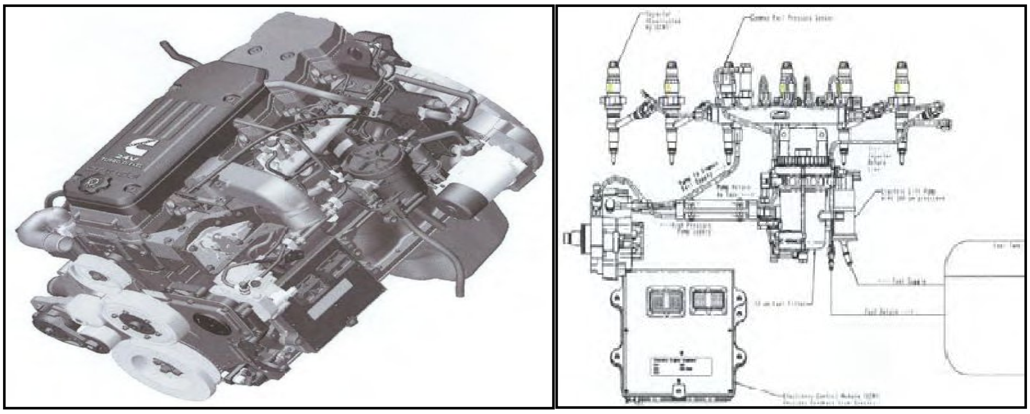

Figure 2.2: Cummins 5.9L diesel engine and common rail fuel system

Source: Memmolo 2008

With the addition of the common rail fuel system in 2003, Cummins was able to achieve24% more power, 10% more torque, and a wider power band over its 2002 engine series(Memmolo 2008). Utilizing the common rail fuel system's high pressures and multiple injections per combustion cycle, increased throttle response, reduced noise, and improvedcold-start times were all achieved, as well as NOx and hydrocarbon emissions reductionsof 25% over the 2002 series (Memmolo 2008). In 2007, Cummins was able to make thisengine series almost 50% quieter with 10% higher common rail fuel pressures as well asother improvements (Cummins, Inc.).

Additionally, this engine utilizes cooled exhaustgas recirculation (EGR) and other air-handling concepts, including Cummins ownproprietary sliding-nozzle Variable Geometry Turbocharger to give optimum boost levelas a function of engine rpm and load. The multi-injection-capable fuel system is thenused to manage in-cylinder conditions to limit emissions.The particulate filter reducesParticulate Matter (PM) levels by 90% of pre-2007 levels" (Cummins, 2008.). These areall real-world examples of advanced diesel technology and their resulting improvements.Diesel engine technology is a significant industry today. There is a lot of research beingdone to maximize efficiencies, power, durability, and meet stringent emissions standards.The basics of the diesel engine have been explained but there are many specifics thathave not been covered. To learn more about the current technologies including thedesigns of injectors, pumps, heads, valves, turbochargers, intercoolers, and much moresee some of the manufacturer's websites including Cummins, Caterpillar, Detroit, JohnDeere, Kubota, or others. Another very good source is the Engine Manufacturer's(Memmolo, 2008).

Association (EMA, 2002), they are an association committed to improving engine technologyas well as emissions controls both domestically and internationally. They provide thelatest publications, legislations, position statements and news reports about issues in engine development.

2.3 BIODIESEL BACKGROUND

Since the use of biodiesel have been widespread and important, aspect is important to know aboutbackground information on biodiesel itself. Biodiesel is a fuel source derived from the latestfuel through a chemical process to meet the specifications prescribed by ASTMD6751 (ASTM Standard, 2004).

2.4 BIODIESEL BENEFITS

There is several reasons increased interest in bio-diesel as a positive environmental impact, safety, and security of energy, the effect of economic and financial incentives. Global warming environmental issues create more central to the prospects for the future. Biodiesel has been proven to be a good option to help address the problem of global warming. The use of biodiesel as a substitute for diesel fuel will significantly reduce emissions hydrocarbon, carbon monoxide, sulfur dioxide, and particles. Nitrogen oxides release that are not fully understood but many studies have shown that they increase the as of 10-15% of the increase and this is only the release of the intensive study for potential improvement. Biodiesel also reduce health risks from transport, storage and handling of fuel. Biodiesel is classified as biodegradable, nontoxic, and is not flammable.

The hotel makes accidental pollution of the environment. Because biodegradable, spills will require attention by making it easier transport. For non-toxic, water pollution or impact on the skin. Quality flash point of biodiesel made more secure storage for not capturing fire easily as gasoline diesel fuel. With fuel prices reaching record high and unstable oil import increased each year, it is clear that there is a need to use resources more fuel. Biodiesel can help maintain the economy while providing a higher level of energy. Since biodiesel to take advantage of animal fats and vegetable oils, increased use of has helped stimulate the marketing of agricultural and created many jobs in the production of biodiesel.

In addition to stimulating the economy of resources it provides to our own fuel, thus reducing the need military protection of foreign oil supplies that have become major issues in politics today. Biodiesel helps preserve natural resources and create jobs that motivate our government to offer financial incentives for them to produce fuel. Government subsidizes fuel based on the number and types of biodiesel blended into gasoline diesel fuel. This helps create a competitive price in the market aggressively. (Cheng, Upanieksand Mueller, 2006).

2.5 BIODIESEL PRODUCTION

Biodiesel can be produced in various processes. The most common aspect isextracting, hydrolysis, and micro emulsions.Most of the production process using a catalyst base extractingusing virgin oil from raw materials like soy, carrots, mustardbean, peanut, sunflower or other oil producing crops. Biodiesel can also be made fromwaste vegetable oil or animal fat, but biodiesel from algae oil has the potential tobecome dominant in the near future. Algae are also used as raw materials of interest forability to quickly and immediately copied the high oil content.Goal of this research is to produce algae-based bio-diesel by aextraction process and tested for performance and emission characteristics.In extraction process, a triglyceride (oil or fat) with alcohol reaction(Usually ethanol or methanol) to form a three and a glycerol ester. To speed up reaction produces an increase, a catalyst (usually NaOH or KOH) is used.

Duringreaction, triglycerides are broken and combined with alcohol and estercatalysts combine the glycerin. When the reaction is complete the results are complete separation of methyl or ethyl esters (biodiesel) and glycerin soap. That glycerin soap settles down and perverted to the increase.

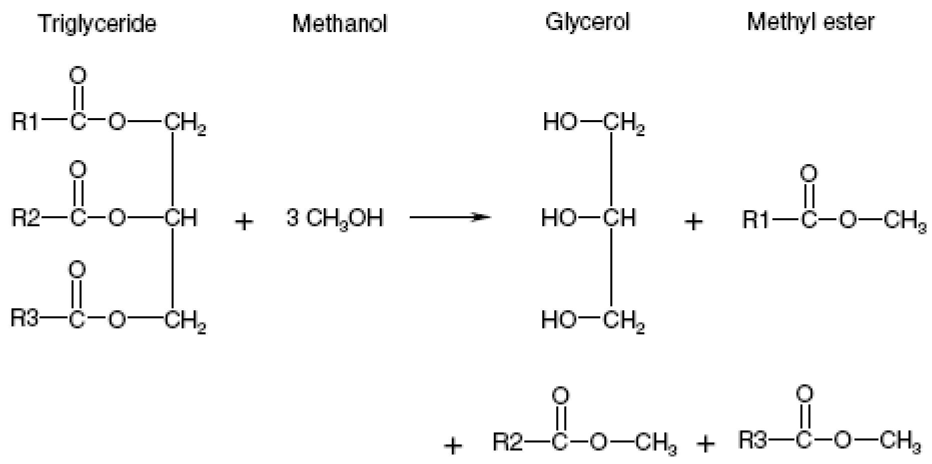

Figure 2.3: Chemical Reaction of triglyceride and methanol to produce biodiesel

Source: Goswani andKreith 2007

Biodiesel is processed further to ensure that no reactant used UN-waste.This is usually done through the process of washing and drying process is not guaranteedwater pollution. This is the basis extraction biodiesel production. This process is sensitive to the catalyst, water pollution, alcohol to triglyceride molar comparison, time, temperature, and other factors. This is very important to know that high biodiesel used will affect all aspects of systems used in the performancethe release of machine wear. Purchase fuel from the retailer in this program is encouraged to review any the application (Cheng, Upanieks and Mueller, 2006).

2.6 PREPARATION OF LABORATORY AND BASE TEST APPARATUS

The main deliverables for this project were in the basic layout of the engine diagnostic testing system. These deliverables were performed in collaboration with instructor engineer and occasionally other students or faculty. The first thing we did was make room in lab for our testing equipment. This involved removing aspects of the previous electric vehicle testing equipment such as part of the chassis dynamometer, scraping the old electric test vehicle, and removing the external battery supplies. Next we acquired an engine which was specked out for our particular needs and supplied by Proton Company Sdn Bhd. This engine was part of a complete power unit included all electrical and cooling systems. It was mounted on a stand and needed a battery and fuel tank to be operational. To couple the engine to our dynamometer we used the services of a driveline shop to make a short driveshaft which connected the flywheel of the power unit to the input shaft on the dynamometer.

In order to insure that the exhaust properly exited the lab, 3” exhaust tubing was run approximately 50’ into lower temperature flexible tubing which reached the exterior of the building. An exhaust back pressure gauge was implemented and compared with factory specifications to insure that high exhaust pressures did not affect the diesel engine. After everything was set up, the system was calibrated and run so that we could begin to focus on our respective research areas. To make sure the existing dynamometer was operating properly, the engine’s power curve was compared to the manufacturer’s supplied data. The data collected for our engine compared very well throughout the operating range showing only slightly less torque at high speeds, likely due to the fact that the manufacturer's data was for the engine operating without a mechanical cooling fan and alternator. In all it took about 12 weeks to complete the basic engine diagnostic testing system.

With all of the purchases we had to make for equipment and miscellaneous items, the total cost of the basic system was around $2000 which included the engine power unit, the fuel and exhaust systems, the mounting and coupling equipment, and other miscellaneous parts. My personal research area involved the development of the thermal measuring and control systems for the engine’s lubrication, coolant and exhaust systems. In addition to this, I set up the system to control and monitor the air and fuel going into the engine. This involved monitoring the air and fuel’s temperatures and flow rates. Finally I had to monitor the environmental and atmospheric conditions to insure accuracy and repeatability of the experiments.

2.7 ENGINE PERFOMANCE OPERATING WITH BIODIESEL FUEL

For future generations of diesel engines also must be able to work with the use ofalternative fuels such as biodiesel and alcohol mix because of the lack of fossil diesel and environmental concerns. The performance of biodiesel is slightly lower than that of diesel fuel, while the same amount of air and fuel is introduced into the cylinder (Senatore, Cardone et al 2000.). Almost no difference between performance of RME and ULSD when comparison is made at the same relative similarity ratio (Senatore, Cardone et al 2000.). Many studies have performed on diesel engines operating with biodiesel as an alternative to diesel fuel(Tsolakis et al, 2007). Most of the researchers have agreed biodiesel fuel that can be used alone or blended with conventional fossil fuel without having to make modifications to the standard diesel engine because biodiesel has properties similar to mineral diesel (Agarwal, 2007; Tsolakis, Megaritis et al. 2007). Although the energy density of biodiesel is lower than diesel fuel, there is almost no difference between the performance of the FMP and ULSD fueled engine when the comparison is made relative to the same air / fuel ratio(Lambda) is used in the machine (Senatore, Cardone et al 2000.).

A study conducted by Labeckas and Slavinskas the four-cylinder diesel machines are controlled by RME and fuel blends with mineral diesel. Machines are inhaled environmental, water cooled compression ignition combustion toroidalspace in the piston head. Tests conducted on five different engine speeds of 1400rpm, 1600rpm, 1800rpm, 2000rpm and 2200rpm. They conclude that the operation of diesel engines with RME consumed more fuel and the low thermal relative to diesel fuel (Labeckasand Slavinskas 2006). Efficiencyof diesel machinesare usually equipped with a turbocharger to upgrade the capability to allow more air cylinder engine train ride. Turbochargers are generally driven pump the energy from the exhaust gas flow. Exhaust gas flows through the turbine, which in turn is used to drive the compressor. The pressure in waste gate is controlled by the compressor to ensure that the pressure in the cylinder is not too high. Alton et al. (2001) has been conducting research on single cylinder diesel engine operating with different types of vegetable oils and their methyl ester. They work with biodiesel fuels from different sources such as raw sunflower oil, crude cotton seed oil, crude soybean oil and their methyl esters, refined corn oil, the world of opium poppies and refined rapeseed oil. Results show that all the fuel on one cylinder diesel engine with only 18% variation in maximum engine power and maximum variation of 10% of engine torque.

Experimental research conducted on diesel engine has shown that burning biodiesel affect the volumetric efficiency of the SIA. This is due the temperature of the exhaust from diesel engines are associated with the combustion event in-cylinder engine and fuel type used in the machine. On the other hand, volumetric efficiency is affected by the discharge temperature (Balusamyand Marappan, 2007). Hasimoglu been doing experiments on four-cylinder turbo charged diesel engines operating with biodiesel and mineral diesel. It concludes that engine volumetric efficiency increased when the machine operates with biodiesel. The combustions biodiesel emitted less heat because of the lower and LCV. Since the exhaust gas temperature is lower than with mineral diesel. Therefore less heat is transferred to the machine, such as intake manifold (Hasimoglu, Ciniviz et al. 2008). This results increased the volumetric efficiency of air intake systems. Kandasamy et al. (2008) has been doing research on single cylinder diesel engine operating with biodiesel and mineral diesel (Kandasamy, Jeganathan et al. 2008). They concluded that the variation of volumetric efficiency is related to exhaust temperature. Volumetric efficiency of engine operation biodiesel is lower due to lower than the temperature of exhaust gas. The low-arrested exhaust air inlet temperature decreased and vice versa.